THE COMPARATIVE NUTRITIVE VALUE OF BUTTERFAT AND CORN OIL FOR THE GROWING RAT

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LORENZO PEDRO ZIALCITA, JR.

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AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ANIMAL NUTRITION IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS, 1944

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INTRODUCTION

The comparative nutritive value of different fats has received considerable attention during the last five years. The Committee on Fats ('43) of the Food and Nutrition Board of the National Research Council in a recent critical evaluation of this problem has reached the following conclusion: "There is not complete agreement in the results from different laboratories as to the comparative value of different fats fed at the same level. Furthermore, with repeated experiments the results are not always the same in a given laboratory. Difference between fats will be found at one time which are statistically significant but which are not reproducible at another time with a new group of rats and a new batch of the same kind of fat."

In view of the apparent contradictions in the literature on the subject, it was thought important to re-study the comparative nutritive value of butterfat and corn oil, and in one test, of coconut oil and rat fat, for the growing rat. To this end, methods were devised to enable a study of the problem involving: (a) the use of very young rats to observe the effects of age, (b) varying amounts of dietary lactose, and (c) the use of equalized and *ad libitum* feeding methods. In addition, the following phases related to the problem were investigated: (1) the possible role of dietary flavor in *ad libitum* feeding studies using growth as a measure of the nutritive value of diets, (2) the urinary excretion of galactose in relation to the presence of fat in the diet and to the kind of dietary fat, and (3) the deposition of carcass fat as affected by isocaloric amounts of butterfat, corn oil, or glucose in the diet.

A solution of the problem, apart from purely theoretical considerations, involves important applications in the field of human nutrition, viz., the much mooted question of margarines and "filled milks" especially in infant feeding.

METHODS

In studying the effects of age, baby rats were paired according to litter, sex, and weight. One group was completely weaned at the age of one week and another at two weeks. These two groups were force-fed and pair-fed with the aid of a hypodermic syringe, the needle of which was modified to suit the purpose. They were fed an artificial liquid milk simulating that of the rat in composition. One member of each pair received fifteen per cent of butterfat, while the other received the same amount of corn oil. At the age of twenty-one days, the rats received synthetic solid milk diets, the composition of which was as follows: sixty per cent extracted skim milk powder, seven per cent casein, six per cent salt mixture, and twenty-seven per cent butterfat or corn oil. These rations were amply supplemented with thiamin hydrochloride, riboflavin, pyridoxine hydrochloride, calcium pantothenate, choline chloride, niacinamide, ascorbic acid, calciferol, carotene, and alpha-tocopherol. An analysis of the gains in body weight and body lengths was made the basis of comparison between the two fats, as well as an analysis of the chemical composition of the carcasses when the rats were nine weeks old.

In the rest of the series involving growth studies, weanling rats were employed and the same basis of comparison was used. The rations offered contained from about thirty-two to forty-eight per cent of lactose. In paired feeding experiments, the number of rats used was never less than eight pairs, while in *ad libitum* feeding, each group comprised not less than ten experimental animals. In every instance, data were statistically analyzed. In paired feed-

ing experiments, Student's "z" test was used, whereas in *ad libitum* feeding, Fisher's "t" test was employed. Individual food consumption was determined whenever food intakes were unrestricted.

In studying the effects of flavor on the nutritive value of diets, the following points were taken into consideration: (a) that the basal diet be as bland as possible, (b) that the different diets be of identical nutritive value, and (c) that the flavoring agents be without any pharmacological effects in the concentrations used. In most of these studies, each group was composed of five weanling rats. Weekly live weights were taken, as well as a record of the food consumption. After an experimental period of three weeks, the rats were sacrificed and measurements taken of the empty body weight gains, body lengths, and total food consumption for each group.

Urinary galactose was determined by a modification of a photocolorimetric method for reducing sugars. Interference due to the possible presence of glucose and other reducing substances was eliminated by fermentation with yeast and treatment with Lloyd's reagent. The accuracy of the procedure followed was attested by recovery trials of pure and added galactose. The specificity of the method was verified with the help of two yeasts, one fermenting galactose and glucose; and the other, glucose alone. Thirty rats, equally distributed in three groups, which received butterfat, corn oil, or an isocaloric amount of glucose, were placed in separate metabolism cages so designed that the urine and the feces were collected separately and quantitatively. The urine was collected under toluene. The collection periods extended for three days and began when the rats had been on their respective diets for not less than two weeks.

The effects of isocaloric diets (butterfat, corn oil, and glucose) on the fat deposition in rats were studied by

determination of the ether extract of the carcasses. There were ten male rats in each group and the experimental period lasted for six weeks.

RESULTS

It was found feasible to wean baby rats at the age of one week. With the foregoing technique, there was an average difference in live weights at the age of twenty-one days between the artificially raised baby rats and those normally nursed, of about ten grams, in favor of the latter. Bilateral cataracts were observed in all cases when the rats were weaned at the age of one week. A level of lactose as low as five per cent was apparently the cause. No such occurrence was encountered in the rats weaned at the age of two weeks.

Growth studies involving paired feeding of rats weaned at one week and at two weeks up to the time they were nine weeks old, and a level of about thirty-two per cent of lactose, failed to confirm claims (Boutwell, Geyer, Elvehjem and Hart, '43a; '43b) that butterfat is inherently superior to vegetable oils in growth-promoting value, especially with very young rats. With rats weaned at two weeks, butterfat seemed to promote greater body length and more fat deposition than corn oil. *Ad libitum* feeding involving weanling rats and the same levels of lactose and of butterfat and corn oil (27%) as before, likewise did not show any superiority of butterfat over corn oil. These results are in complete agreement with those obtained by Deuel and associates ('44).

An increase of dietary lactose from about thirty-two to forty-eight per cent, using the paired feeding method, brought about greater average body weight gains in favor of the butterfat fed rats. This difference, however, was not statistically significant ($P = 0.084$). Moreover, the

difference in gains could well be attributed to a greater deposition of fat in the butterfat than in the corn oil group. A comparison involving weanling rats, with paired feeding and a forty-eight per cent level of lactose, disclosed butterfat and coconut oil to be similar in growth-promoting value and rat fat to be definitely inferior to either butterfat or corn oil.

Whereas equalized feeding did not show any superiority of butterfat over corn oil, the differences in favor of butterfat, as shown by uncontrolled feeding, were greater and significantly so. Statistical treatment of the data showed greater experimental error when food intakes were unrestricted. Furthermore, statistical evidence indicates that if the corn oil rats had eaten as much as the butterfat rats, they would have made equivalent gains in body weight.

The flavors of two diets in themselves accounted for a difference in growth thru differences in food intakes, especially when their influence was exerted in opposite directions in comparison with a flavorless diet.

With an intake that varied from 3.36 to 5.04 grams of galactose daily per rat, the presence of butterfat, corn oil, or an isocaloric amount of glucose in the diet, did not affect the urinary excretion of galactose. The amount excreted expressed in per cent of the galactose ingested were: for the butterfat group, 30.7; glucose, 28.6; and corn oil, 20.7. The mean differences between groups were not statistically significant. The galactose excretion may be assigned to a purely alimentary galactosuria.

A comparison of the effects of butterfat, corn oil, or an isocaloric amount of glucose on the deposition of fat in rats revealed that butterfat and corn oil were similar. Much lower values were obtained in the glucose group. Rats fed butterfat had 10.55% of ether extract; those fed

corn oil, 9.92%; and those fed glucose, 8.80%. This can be accounted for by the higher specific dynamic action of carbohydrates over that of fats, and consequently, a higher availability of the energy derived from fats.

CONCLUSIONS

1. Apart from differences in vitamin content, corn oil, coconut oil, and butterfat, are essentially equal in growth-promoting value for the rat in diets containing up to forty-eight per cent of lactose. Rat fat is definitely inferior in this respect.

2. The amount of an adequate diet consumed daily by a growing rat may be influenced significantly by flavoring substances possessing no known physiological effects in the concentrations used, except a stimulating or a depressing effect upon appetite. Hence, in *ad libitum* feeding, differential growth rates may be secured upon different diets irrespective of differences in nutritive adequacy.

3. No evidence was secured that maximal utilization of galactose in metabolism is dependent upon the presence of fat in the diet.

4. The rate of deposition of fat in the body of a growing animal is increased when isocaloric amounts of fat are substituted for carbohydrate in the diet. This is presumably due to a higher specific dynamic effect of carbohydrate than of fat.

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VITA

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